Automated Weeders: Where Are They Headed? Steven A. Fennimore, University of California, Davis, at Salinas, CA, safennimore@ucdavis.edu

Vegetable crops consist of dozens of crops and have varying weed management systems based on the needs of the crop. The high value of vegetable crops, limited markets and potential liability to registrants results in very few new herbicides in queue for vegetable crops. Hand weeding is very important for vegetable weed control programs due to many reasons including inadequate herbicide registrations. However, agricultural labor shortages are common and growers report difficulty in finding enough people for many farm tasks including hand weeding. Therefore, there is an overwhelming need to find cost-effective technologies to control weeds in vegetables.

There are at least three brands of automated cultivators, also called "intelligent cultivators": Robocrop, Robovator and Steketee IC. These cultivators have machine vision systems, i.e., cameras linked to a computer, that detects the row pattern and identifies the crop based on planting pattern. Plants that are not in the row pattern are assumed to be weeds and targeted for removal. The information about the location of the crop is used to control an actuator – in this case a cultivator blade, that removes the weeds around the crop including the intra-row space, much the same as a human hoe hand.

Lettuce has for decades been seeded and thinned to desired stands by a hand weeding crew with hoes. However, decreasing labor availability and increasing costs for lettuce hand thinning has resulted in need for labor saving technologies. Recently, commercial machines capable of robotic lettuce thinning have been developed to machine-thin lettuce to the desired final crop density, helping growers reduce the cost to hand thin the crop. These systems typically utilize machine vision technology to detect plant location and accurately direct herbicidal sprays, such as carfentrazone to thin crops to desired stands. The lettuce thinners typically treat 13% of the surface area of a lettuce field spraying an intermittent band 4 inches wide with two plant lines per 40 inch wide raised bed. Within the length of the plant line, about 30% is left unsprayed to preserve the "saved" lettuce plants.

Cultivator blades and weeding knives are not new technology. What is new is the combination of steel cultivator knives with automation technology to create a new type of weed control tool. The device that contacts and kills the weed is called the "actuator". Cultivator knives are just one such actuator – there are other possibilities such as abrasion (i.e. sand blasting), flame, superheated steam, hot oil, lasers, stampers and high pressure water jets. Intelligent cultivators work well in low density crops like lettuce, pepper and tomato where there is adequate space to separate the crop plants and differentiate them from weeds. However, high density crops such as carrot and spinach will require a different approach such as a grid spraying system. In the grid system the automated weeder would identify the weeds and differentiate them from the crop. The system would then control the weeds with a physical tool such as a flame burst or chemical spray targeted to a small spot such as a 0.5" by 0.5" square.

There are some interesting questions pertaining to development of intelligent technology. For example, herbicide molecules can be patented and protected from infringement during the duration of the patent. Machines on the other hand are quite flexible and there are often multiple ways to perform weed removal allowing for many models of weeders that do not infringe on the designs

of others. Regulatory hurdles are less for physical weed control devices than for herbicide registrations, which may mean the cost of entry, is much less with machines than for herbicides. Will this flexibility discourage or encourage development of this technology? Another interesting question is who will develop this technology? Development of intelligent cultivators are very different from development of herbicides. Will chemical companies develop intelligent weeders to promote sales of their products? These questions and others will be explored in the presentation.